J2
409/2:86
c.2

CHES STUDIES
A Special Report Series by
THE STATE CENTER FOR HEALTH AND ENVIRONMENTAL STATISTICS
P.O. Box 29538, Raleigh, N.C. 27626-0538

No. 86

November 1994

AN ECOLOGIC STUDY OF CANCER IN COMMUNITIES NEAR PAPER MILLS

N.C. DOCUMENTS
CLEARINGHOUSE

DEC 9 1994

N.C. STATE LIBRARY
RALEIGH

by

Kathryn McLawhorn and Tim Aldrich, Ph.D.

ABSTRACT

There are 16 paper mills that operate in 12 North Carolina counties. This special study evaluates the association of paper mill emissions and the occurrence of selected cancers in these counties. Paper mills that use a bleaching process were determined to be ones that would most probably have effluent or emissions with dioxin contaminants. The cancers selected for study were liver, stomach, soft tissue sarcomas, and non-Hodgkin's lymphoma; these cancer sites were associated with paper mill employment or exposure to dioxins based on a review of the scientific literature.

Each of these cancers has high case fatality rates so that mortality data were considered a good estimate of cancer incidence. Mortality rates of the six counties with paper mills using bleaching processes were examined in detail for evidence of excess cancer occurrence of these specific types. Geographic analyses were performed to evaluate spatial patterns of residence for cancer cases.

The latter stages of the study focused on Craven and Haywood counties due to elevated cancer rates and trends in cause-specific cancer rates over the 1970-1990 interval. Proportionate mortality ratios were calculated to assess the patterns of cancer occurrence within the counties. Geographic evaluations were made for patterns that suggest hazardous exposures through the environment (e.g., air or water borne). Further, case history studies were made including assessments of occupational exposures and drinking water sources. An analysis of breast cancer incidence was added for Haywood County.

No specific association could be discerned between the cases of cancer for the selected types and emissions from paper mills.

DEHNR NORTH CAROLINA DEPARTMENT OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES

INTRODUCTION

Sixteen paper mills operate in North Carolina. These paper mills are located in 12 counties (Figure 1). In 1991, several citizens of communities around some of these paper mills contacted the Central Cancer Registry (CCR) about possible excess cancer occurring in residents living near the paper mills. Since most of the communities around paper mills were rural, few specific types of cancer cases may occur, thereby limiting the statistical precision of data analyses. After four cancer cluster reports indicated concern for paper mill emissions, a special study of all paper mill communities was begun. It was believed that a statewide approach to evaluating these reports would increase the chance of detecting any evidence of excess cancer occurrence associated with living near paper mills.

BACKGROUND

This evaluation sought to determine whether there was evidence of excess cancer risks that could be related to emissions from paper manufacturing processes; dioxin exposures were a particular concern. The scientific literature for the previous decade was reviewed to determine which type(s) of cancer are associated with the recognized emissions from paper mills. Based on this literature review, and with concurrence from the state toxicologist, the cancers most likely associated with paper mill emissions are liver cancer, soft tissue sarcoma, stomach cancer, and Non-Hodgkin's lymphoma (NHL).[1,2,3,4,5]

In the early phase of this study, several potential routes for environmental transport of potentially hazardous emissions from paper mills were identified. These were air transport, surface water transport (which was alleged by citizens in their reports to the CCR), and ground water contamination. There were uncertainties about which communities might be the ones most heavily exposed to emissions from nearby paper mills. Consequently, a decision was made to inspect the cancer occurrence rates in each county as a whole as well as some of the surrounding counties.

Description of the Paper Manufacturing Process

In March 1992, a meeting was held with the North Carolina Pulp and Paper Council's Environment, Health, and Safety Committee, which included representatives from three of the largest paper manufacturers operating in the state. These representatives provided information on the number of employees at each paper mill, the product output per day, years in operation and significant process modifications during that time, and the details of manufacturing processes, including the chemicals used.

Information on the other paper mills was obtained from the North Carolina portion of *Lockwood-Post's Directory of Pulp and Paper Mills in the United States, 1992.*[6] It gave the location of each pulp and paper mill in the state and described the type of mill, its products, and the manner of bleaching process the mill used.

Of the 16 North Carolina mills, six use a Kraft Mill bleaching process to manufacture paper and pulp.[7] This process involves chemically cooking wood chips in a digester with a chemical called white liquor. Lignin, which binds cellulose fibers together in wood, is dissolved during the cooking process. The contents of the digester are then transported into a blow pit. In the brownstock washing stage, the spent white liquor and dissolved lignin are separated from the cellulose pulp.

Due to its brown color, it is necessary to bleach the pulp with chlorine, chlorine dioxide, and/or other chemicals. In recent years, pulp and paper mills have been substituting more chlorine dioxide for chlorine in the bleaching stages. The advantages of using chlorine dioxide are that it bleaches better, increases the yield of bleached pulp, and reduces pollution between the bleaching stages. The concentration of chlorine dioxide in the gas, however, must be kept below about 12 percent by volume because higher concentrations of the gas become unstable and decompositions can cause safety hazards.[8] Finally, the bleached pulp is pressed and converted into paper.

A closed cycle Kraft Mill process, which incorporates the process described above, attempts to reduce the volume of waste it produces through reuse and recycling. Its features include complete countercurrent reuse of water; reuse of black liquor condensates; salt removal and control; and spill control, containment, and reinjection. The results include more efficient use of heat, chemicals, and fibers, and increased output.[9]

Smoke stack emissions at these paper mills result from the combustion of coal in power boilers, recovery boilers, lime kilns, and pulp systems. Products of other associated processes also contribute to smoke stack emissions.[9] The emissions include particulates, sulfur dioxide, carbon dioxide, chlorine dioxide, methanol, sulfuric acid, and miscellaneous other chemical compounds. Effluents discharged into area water sources contain several chemicals, including acetone, ammonia, chloroform, and zinc. All emissions and effluents are regulated and controlled by federal, state, and local agencies in an effort to minimize the formation of dioxin and other harmful compounds.[10] Studies in North Carolina by the Environmental Protection Agency (EPA) have revealed dioxin contamination in fish from streams near pulp and paper mills that use bleaching processes.[11]

Earlier Occupational Study

The National Institute for Occupational Safety and Health (NIOSH) conducted an epidemiologic study in the 1980's that is relevant to this study.[3] NIOSH investigated the relationship of employment at a paper mill in Maine and the cancer experiences of the workers. Elevated rates of stomach cancer and malignancies of the hematopoietic system were found. Suspected relevant exposures included wood dusts, sulfur compounds, and other chemicals. Although no definitive conclusions were reached, the increased risks for these two cancers suggested that health hazards existed at the mill. The study recommended surveillance at the study site and at other mills that use the same or similar processes.[3]

METHODS

Once the information on each paper mill in North Carolina was gathered, the approximate location of each facility was mapped (Figure 1) and the 1986-1990 cause-specific, age-adjusted mortality rates for the four selected cancer types were calculated for each of the 12 counties where the paper mills were located (Table 1). In addition, the cancer mortality rates of the six counties with paper

Table 1
1986–1990 Age-Adjusted Mortality Rates
(1970 U.S. Standard) for Selected Cancers in North Carolina Counties with Paper Mills

		Sites			
County	**City/Town with Paper Mill(s)**	**Liver**	**Stomach**	**Soft Tissue**	**NHL**
Caldwell	Patterson	1.5	3.8	1.0	3.2
Chatham	Moncure	2.2	3.6	0.8	5.1
Columbus	Riegelwood	2.1	4.5	1.9	5.0
Craven	New Bern	2.7	7.3	1.3	4.1
Halifax	Roanoke Rapids(2)	1.2	5.8	0.3	5.3
Haywood	Canton	2.3	3.8	0.2	7.4
Jackson	Sylva	2.5	2.8	1.5	3.9
Mecklenburg	Charlotte	3.2	4.5	0.8	6.2
Richmond	Rockingham (2), Cordova	3.1	4.5	1.9	5.4
Robeson	Lumberton, Maxton	1.9	4.7	0.8	4.0
Transylvania	Pisgah Forest	0.5	4.7	0.7	7.1
Washington	Plymouth	3.2	4.9	2.2	3.9
North Carolina		2.2	4.4	1.1	5.5

mills that use a bleaching process were examined in greater temporal and site-specific detail. After these evaluations, eight counties were eliminated from further study because their cancer rates were either not elevated over those of the state, the numbers of cancer cases were too few to permit a confident interpretation of the rates, or the paper mill in question did not use a bleaching process.

Four counties with paper mills using bleaching processes (Transylvania, Washington, Craven, and Haywood) and two surrounding counties (Buncombe and Martin) were selected for further study. County-specific 1970–1990 mortality rates of the four selected cancers were examined for temporal trends (Craven and Haywood County data are shown in Figures 2-3). In addition, the incidence cases for 1990 and the mortality cases for 1980–1990 were identified for each county. Name, address, age, sex, and race for each incidence case and death, as well as the cell type of the cancer for each incidence case were determined. In addition, due to the small number of cases of soft tissue cancer in these four counties, this type of cancer was eliminated from further study.

The approximate residential location for each incidence case of the three remaining cancers (liver, stomach, and non-Hodgkin's lymphoma) was placed on detailed area maps to visually assess whether any spatial patterns existed among the location of the paper mill, the route of distribution for emissions and effluent from the mill, and the case's place of residence. A sample map from Haywood County is shown in Figure 4. Rivers and other topographic features (e.g., mountain valleys) also were considered as potential routes of transport. Washington, Martin, Transylvania, and Buncombe counties were excluded since no clear spatial patterns were discernable among the cancers in those counties.

The two remaining counties received closer examination because of the consistently elevated stomach cancer rates in Craven County (Table 1 and Figure 2) and the rising temporal trends in mortality for non-Hodgkin's lymphoma and for liver cancer in Haywood County (Figure 3). The next step in the systematic evaluation of the cancer occurrence patterns for these two counties was an attempt to study possible localized excesses of the specific cancers. The occurrences of cancer in people living near the paper mills were examined, by zip codes (Table 2). Proportionate cancer mortality ratios (PCMR) were calculated for residential zip code areas using the following formula:

$$\begin{array}{l}\textit{PCMR}\\ \textit{(proportionate}\\ \textit{cancer mortality}\\ \textit{ratio)}\end{array} = \frac{\begin{array}{c}\textit{(specific cancer death in zip/}\\ \textit{total cancer death in zip)}\end{array}}{\begin{array}{c}\textit{(specific cancer death in county/}\\ \textit{total cancer death in county)}\end{array}}$$

Ratios close to 1.0 indicate that cancer occurrence in the zip code area was similar to the cancer occurrence in the county as a whole. In all calculations, the numbers of cancer cases were quite small; this means that specific PCMRs could be quite unstable. Statistical testing was done to determine if any of the PCMRs were significantly elevated.[12]

Individual case histories were examined for occupational titles specifically related to paper mill processes (e.g., "bleacher"; "cooker operator") and the industry of employment as an indication of potential exposure to paper mill emissions. This search for additional cases that could potentially be related to exposure to paper mill emissions was an attempt to find those who did not live close to the paper mills, but who might have been exposed to paper mill emissions in their work place.

The basis for this search for cases, linked to paper mill emission by occupational exposures, was the recognized pattern that in rural areas workers frequently live quite a distance from where they work.[13] Also, information was sought about source of drinking water and duration of residence for cases that resided in key locations (e.g., close to the paper mill or near other cases).

Table 2
1988–92 Proportionate Cancer Mortality Ratios (PCMRs) for Haywood and Craven County Zip Codes in Proximity to Paper Mills

HAYWOOD COUNTY

Zip Code	Town	Cancer	No. Deaths	PCMR	Statistical Significance
28716	Canton	Liver	1	0.5	ns
		NHL	7	0.8	ns
28721	Clyde	Liver	2	2.4	ns
		NHL	3	0.9	ns
28738	Hazelwood	NHL	2	1.8	ns

CRAVEN COUNTY

Zip Code	Town	Cancer	No. Deaths	PCMR	Statistical Significance
28560, 28562	New Bern	Stomach	16	1.1	ns

Before the results of this study were released, the CCR was contacted by a researcher who had examined the effect of paper mill effluent on fish in Haywood County. He requested that the CCR perform an analysis of the breast cancer risk among residents in Haywood County who were potentially exposed to paper mill effluents.[14] Breast cancer incidence for 1990 and 1991 was evaluated using PCMRs (morbidity) for Haywood County zip codes near that paper mill because of a possible connection between chlorinated hydrocarbon exposure and breast cancer risk (Table 3).[15]

RESULTS

As shown in Figure 2, Craven County's stomach cancer rates have been increasing over the past 20 years. During the 1986-1990 period, the average rate was elevated over the state rate (Table 1). For Haywood County, the non-Hodgkin's lymphoma rates were increasing over the period; liver cancer rates were also increasing (albeit at lower rates) (Figure 3).

In Craven county, there was no evidence at all of a spatial pattern to the residences of the cancer cases. Further, no links to occupation or drinking water were apparent. There were slightly elevated PCMRs in the Haywood County communities of Hazelwood and Clyde (Table 2), but they did not reach statistical significance. Again the intensive review of other case characteristics (e.g., drinking water source, occupation) failed to identify any factors that would justify additional work on the basis of so few cases.[16,17]

As a part of the accessory study of breast cancer risk associated with paper mill effluents in Haywood County, the residences of incidence breast cancer cases in 1990 and 1991 were mapped. A sample of some of the mapped cases is presented in Figure 5 to illustrate the improvement in geographic analysis capabilities in the CCR. No evidence of excess breast cancer incidence was found with the geographic study or from the PCMRs calculated for the communities nearest to the paper mill (Table 3).

Table 3
1990–91 Proportionate Cancer Mortality Ratios (PCMRs) for Breast Cancer in Haywood County Zip Codes in Proximity to Paper Mills

HAYWOOD COUNTY

Zip Code	Town	Cancer	No. Cases	PCMR	Statistical Significance
28716	Canton	Breast	36	1.2	ns
28721	Clyde	Breast	10	0.9	ns
28738	Hazelwood	Breast	6	1.4	ns

CONCLUSIONS

In response to citizen concerns, the CCR analysed excess cancer incidence and mortality in counties with paper mills. Although some of those counties had elevated mortality rates for cancer of the liver, stomach, soft tissue, and non-Hodgkin's lymphoma, this study found no evidence to link excess cancer occurrence to residential proximity to paper mills. Continued public health surveillance is recommended for cancer incidence and mortality in these communities because of the plausibility of a potential hazardous exposure (i.e., dioxin) and the observation of higher rates of stomach cancer in Craven County and non-Hodgkin's Lymphoma in Haywood County.

This study had several limitations. The small numbers of specific cancer cases precluded tests with good statistical power. Also, there was substantial uncertainty about the likelihood of exposure to paper mill emissions. Finally, there were too few case-specific details, (life style factors and histories of occupational exposures) to permit one to attribute excess cancer occurrence to paper mill related factors versus other sources of risk for these cancers.

REFERENCES

1. Williams, G.M. and Weisburger, J.H. (1986). *Chemical Carcinogens*, IN Toxicology: The Basic Science of Poisons, 3rd. Edition. Klaassen, C.D., Ambur, M.O. and Doull, J. Editors. Pub. MacMillian Publishing Co., New York, New York. pp. 124-125, 132.

2. Murphy, S.D. (1986). *Toxic Effects of Pesticides,* IN Toxicology: The Basic Science of Poisons, 3rd. Edition. Klaassen, C.D., Ambur, M.O. and Doull, J. Editors. Pub. MacMillian Publishing Co., New York, New York. pp. 555.

3. Galson, S.K. (1990). Hazard Evaluation and Technical Assistance Report: Boise Cascade. Pub. National Institute of Occupational Safety and Health, Hazard Evaluation and Technical Assistance Branch, Cincinnati, Ohio.

4. Zahm, S.H. and Blair, A. (1992). Pesticides and Non-Hodgkin's Lymphoma. *Cancer Research* (Supplement); 52:5485s-5488s.

5. Morrison, H.I., Wilkins, K., Semenciew, R., Mao, Y., Wigle, D. (1992). Herbicides and Cancer. *Journal of the National Cancer Institute*, 84:1866-74.

6. Lockwood-Post's Directory of Pulp and Paper Mills in the United States, (1992). Pub. Miller Freeman, Inc., Atlanta, GA, pp. 105-108.

7. *Paper Mill Questionnaire*, (1992). Pub. Champion International Corporation. Canton, NC. pp. 4-14.

8. M.G. Halpern, (1981). Pulp Mill Processes: Developments Since 1977, Pub. Noyes Data Corporation. Park Ridge, NJ.

9. A.M. Springer, (1986). Industrial Environmental Control: Pulp and Paper Industry. Pub. John Wiley & Sons, New York, NY.

10. Edde, H. (1984). Environmental Control for Pulp and Paper Mills, Noyes Publication, New Jersey.

11. Fish Tissue Dioxin Levels in North Carolina, 1990 Update (1991). North Carolina Division of Environmental Management, Water Quality Section, Raleigh, NC.

12. Hardy R.J., Schroeder G.D., Cooper, S.P., Buffler P.A., Prichard H.M., and Crane M. (1990). A Surveillance System for Assessing Health Effects from Hazardous Exposures, *American Journal of Epidemiology*, 132:S32-S42.

13. Evaluating Clusters of Adverse Health Outcomes, Aldrich, T.E., Savitz, L.A. and Wittie, P., IN *Geographic Methods for Health Services Research*, Eds. Ricketts, T.C., Savitz, L.A., Gesler, W.M. and Osborne, D.N., Pub. University Press of America, Lanham, Maryland, 1994.

14. Adams, S.M., Crumby, W.D., Greenly, M.S., Shugart, L.R. and Saylor, C.F. (1992). Responses of Fish Populations and Communities to Paper Mill Effluents: A Holist Assessment. *Ecotoxicology and Environmental Safety*, 24:347-60.

15. Wolff, M.S., Toniolo, P.G., Lee, E.W., Rivera, M. and Dublin, N. (1993). Blood Levels of Organochlorine Residues and Risk of Breast Cancer. *Journal of the National Cancer Institute*, 85:648-52.

16. Aldrich, T.E. and Leaverton, P. (1993). Sentinel Indicators for Emerging Environmental Health Problems, *Annual Reviews of Public Health*, 14:205-17.

17. Persson, B., Fredriksson, M., Olsen, K., Boeryd, B. and Axelson, O. (1993). Some Occupational Exposures as Risk Factors for Malignant Lymphomas. *Cancer*, 72:1773-8.

PAPERMILLS IN NORTH CAROLINA

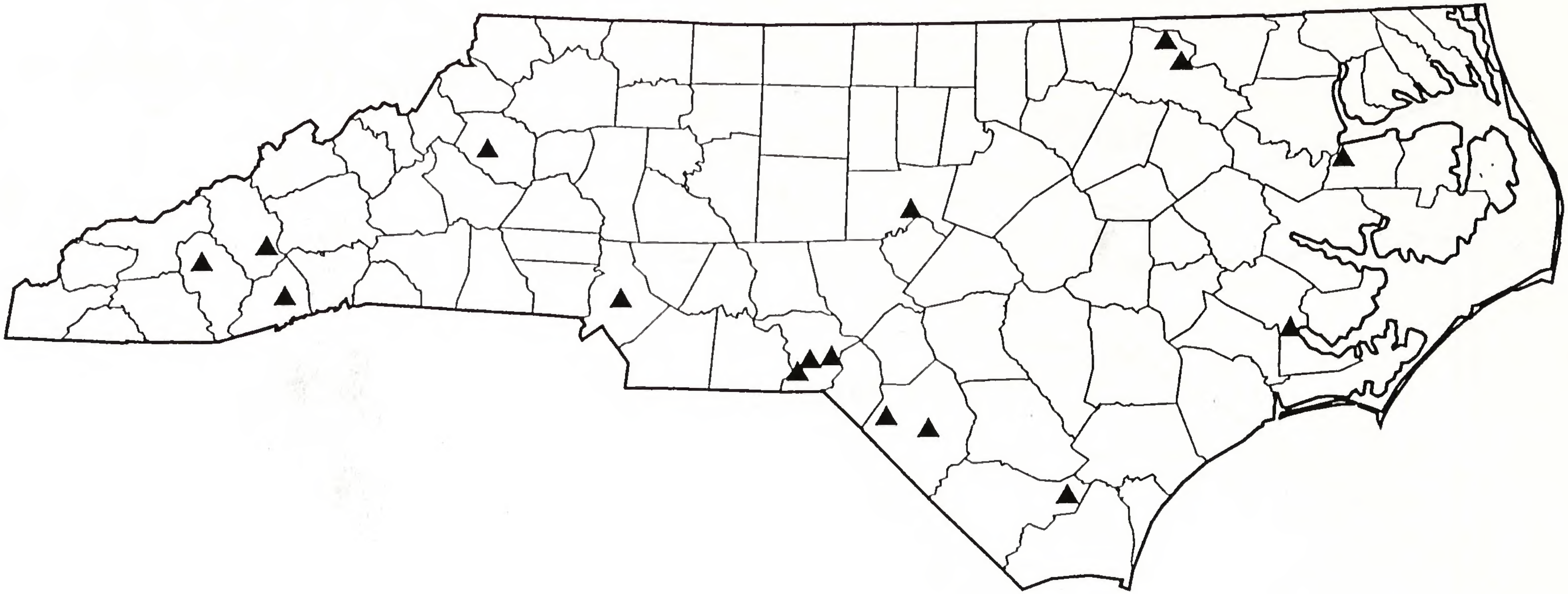
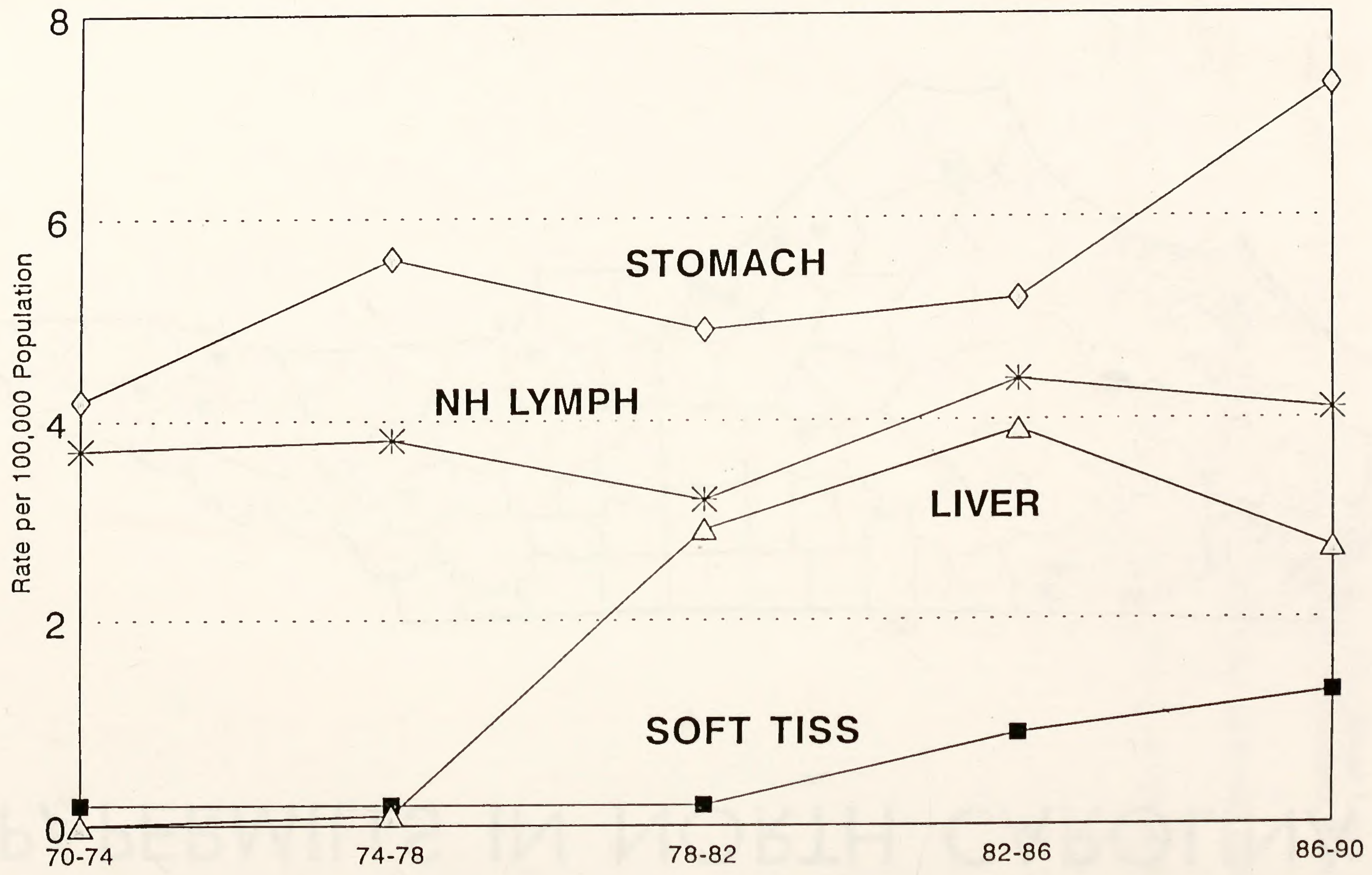


Figure 1

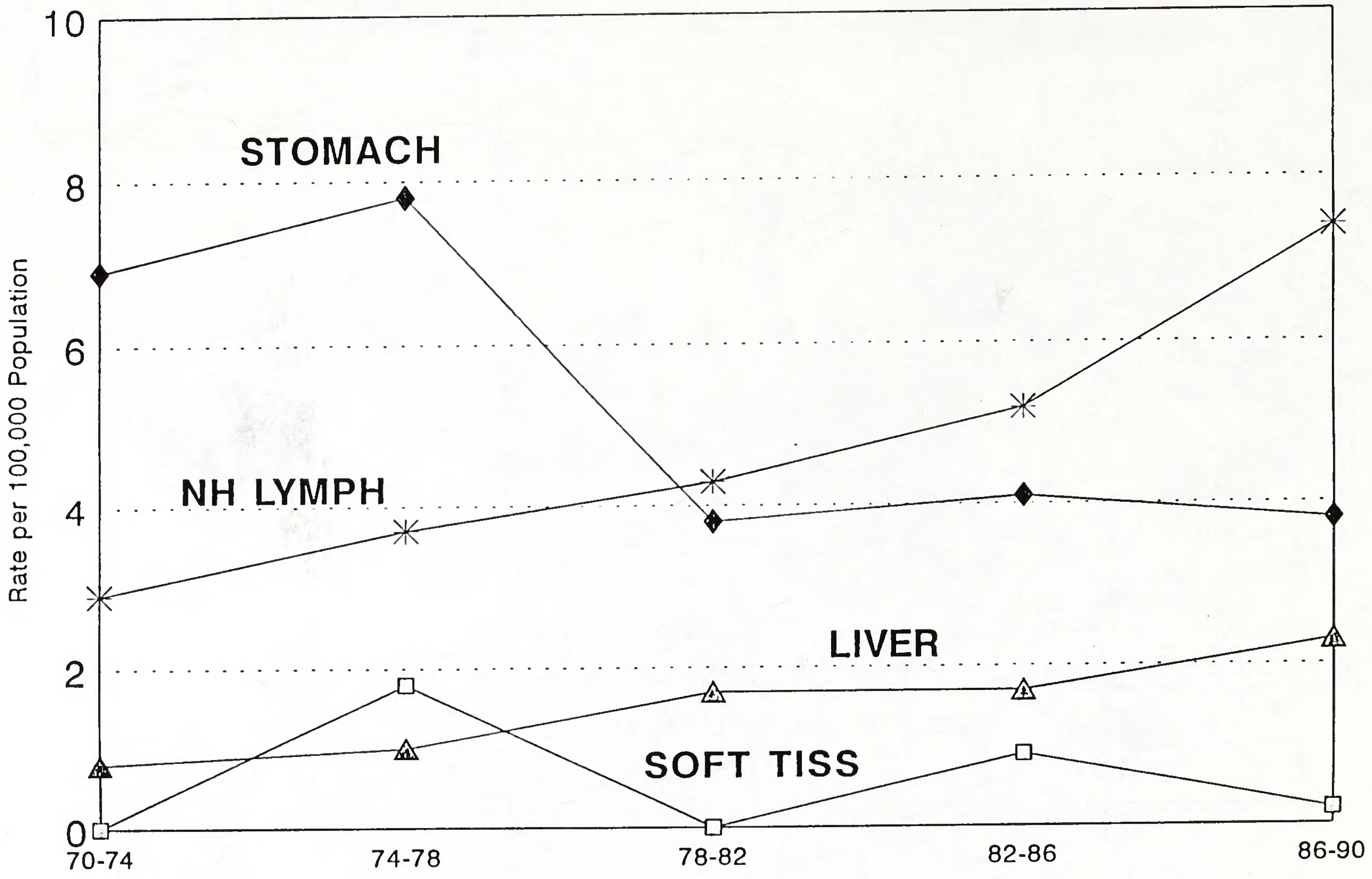
Age-Adjusted Cancer Death Rates by Site
Craven County, 1970 - 1990



Adjusted to 1970 U. S. Population

Figure 2 – Time Series of Cancer Mortality in Craven County

Age-Adjusted Cancer Death Rates by Site
Haywood County, 1970 - 1990



Adjusted to 1970 U. S. Population

Figure 3 – Time Series of Cancer Mortality in Haywood County

STATE LIBRARY OF NORTH CAROLINA
3 3091 00584 5938

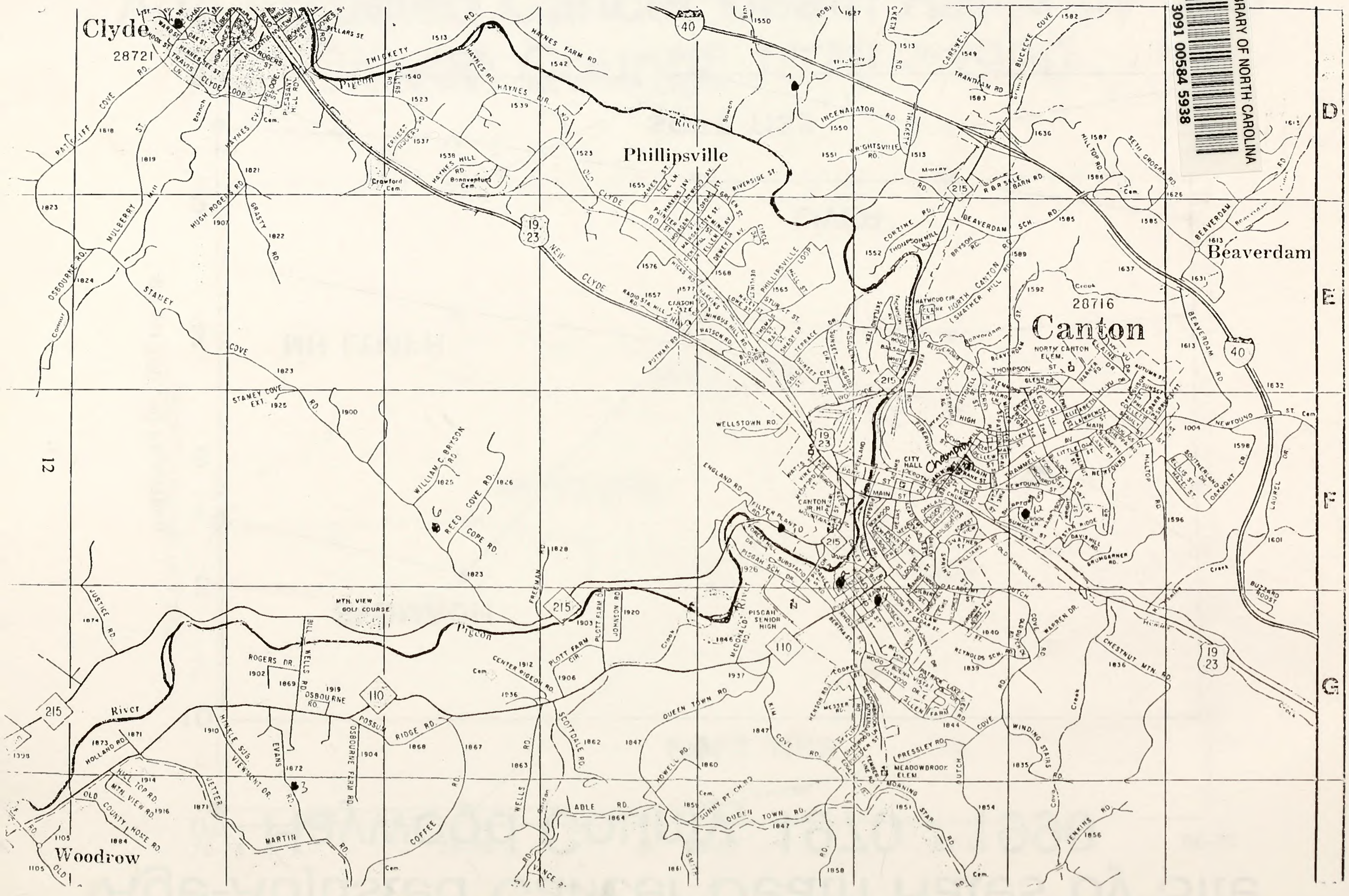


Figure 4 – Cancer Incidence and Mortality in Haywood County

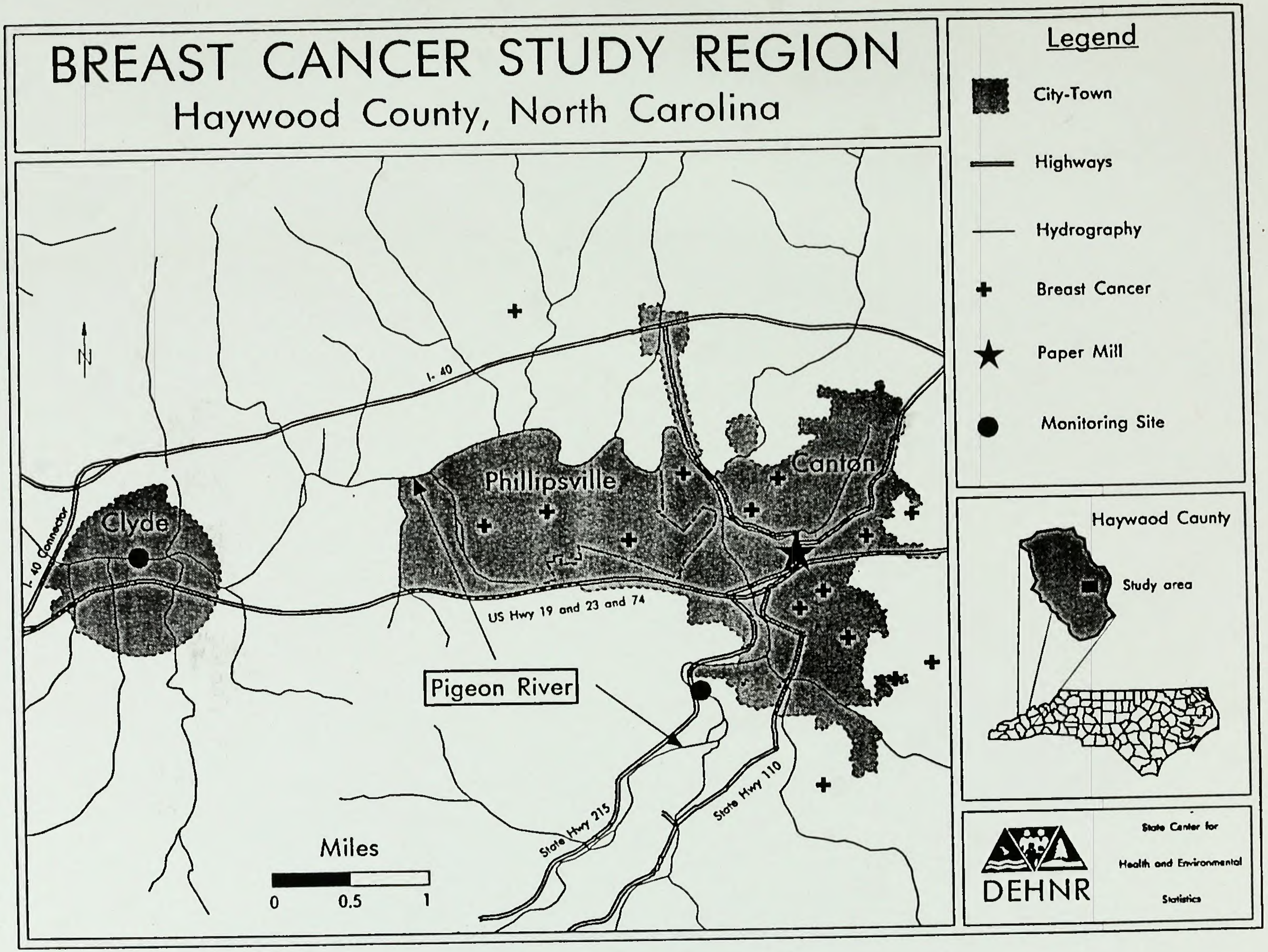


Figure 5 – Breast Cancer Cases in Haywood County (1990-91)

Department of Environment, Health, and Natural Resources
State Center for Health and Environmental Statistics
P. O. Box 29538
Raleigh, N.C. 27626-0538
919/733-4728

BULK RATE
U.S. Postage
PAID
Raleigh, N.C. 27626-0538
Permit No. 1862

750 copies of this public document were printed at a cost of $171.20 or 23¢ per copy.